was taken in Fair Haven, the great bay at the north-west angle of the main island, but it may be in Magdalena Bay. Incidentally, I may also mention that the geographical nomenclature employed is very inaccurate, thus the name Mount Hedgehog, which belongs to Hornsundstind, is given to a hill on the east coast, and other names are likewise misapplied. Mr. Arnold Pike is called Mr. Pikes.

The Swedes measured their base at Treurenberg Bay, the Russians theirs near Whales Point (Fig. 2). For this purpose they used the Jäderine apparatus, in which a wire consisting of Guillaume metal (a steel and nickel alloy), about 25 metres long and 1·7 mm. thick, is supported at a fixed tension on a series of tripods, used in pairs successively. By this means the base was measured in four days, each measurement being repeated four times with two different wires. The limit of error is stated to be not more than 1 in 400,000.

At the beginning of the season of 1899 the Russians went up to Horn Sound, and began establishing their winter station close to a spot where Garwood and I spent a week in 1897, so that it was not, as they imagined, "a spot where for more than two centuries no human being has lived." Here, in fact, throughout the eighteenth and part of the nineteenth centuries the Russians themselves had a trappers' winter establishment. While the houses were building, the observers went for a trip to the north, but the weather was very bad. Then they went round to Wybe Jans Water (which they call Storfiord) to commence the observation of their ten triangles, one of which had a side 130 kilometres long. They found the sea free of ice—an unusual condition to the eastward—and were able to land anywhere with ease. They were astonished by the relatively rich vegetation on Anderson Island. Not until August 6 could they actually begin observations from the signal point at Cape Lee, where they spent twenty days and could only work on three. They had to abandon the place before their work was done. The wintering party settled in whilst the others returned home. The winterers next spring made overland expeditions to Mount Keilhau, and began work there. In June, 1900, the other observers returned from Europe. It was several weeks later before the Keilhau observations were complete. Meanwhile, others were exploring the interior of the ice-sheet from Klaas Billen Bay, to find a junction signal-point for the Swedes and Russians. They succeeded after forty-five days, and built a pyramid on Mount Tchernycheff, a point first discovered by me in 1897. At Whales Head the observations were very protracted, and ice cut the observers off, so that it was long before they could get away. An expedition went overland to relieve them from Low Sound (wrongly called Van Mijen Bay). This was about all that was accomplished that season.

In 1901 the weather was much more favourable. The Russian base was measured near Whales Point. The remaining stations were occupied as far as Thumb Point, and the work completed. A final visit was paid to the abandoned winter station, and the expedition returned home in safety and content.

MARTIN CONWAY.

SEISMOMETRY AND GÉITE.

OBSERVATIONS on earthquakes which have transmitted vibrations to all points upon the surface of our globe apparently lead to conclusions respecting the physical nature of its interior. The following notes indicate the character of these conclusions, and at the same time suggest directions in which these may be harmonised with astronomical and other requirements.

Within a radius of 10° or 20° of a centrum, the velocity of transmission of the larger earthquake waves varies between 1·8 and a little more than 3 km. per second, such variations being usually attributed to the nature of the medium through which the waves have passed. Beyond these limits, and up to 165°—that is, to near the antipodes of an origin—speeds which are practically constant prevail.

The large waves have a velocity which, if regarded as "arcual," is constant at about 3 km. per second, whilst the preliminary tremors, if it is assumed that they travel along paths approximating to chords, quickly attain a velocity exceeding 9 km. per second.

The constant velocity for the large waves and the high velocity for their precursors preclude the idea that either of them were transmitted through the heterogeneous quasi-elastic crust.

If the large waves are regarded as the outcroppings of mass waves, then as pointed out by Dr. C. G. Knott the law which would govern their transmission so that their apparent arcual velocity should be constant would be "most complicated and improbable." Considering this uniformity of speed in conjunction with observations which indicate that as they pass beneath country after country they give rise to tilting phenomena on the surface, and that the amounts of tilting recorded at different stations in areas like Great Britain are, at least for the smaller disturbances, practically equal, the conclusion arrived at is, that the large waves of earthquakes are transmitted through a comparatively homogeneous medium beneath the crust, which, as they pass, is forced to rise and fall like a raft upon an ocean swell.

If the preliminary tremors followed the same path as the large waves, then their velocity would not be constant, but would vary from 3 km. per second in the vicinity of their origin to 15 km. per second as they approached the antipodes. On the contrary, if it is assumed that the paths approximate to chords, then for chords of 10°, 20°, 30°, 40°, 50°, 60°, 80°, 90° and 150° the corresponding average velocities in kms. per second are from 3 to about 5, 7·3, 8·1, 8·5, 8·5, 8·8, 9·0, 9·3 and 9·3—these being minimum rather than maximum values.

The lower of these velocities, all of which are average values deduced from observations dating back to 1889, may be due to the fact that they refer to the shorter chords, a considerable portion of which lie within and near what is assumed to be the crust of the earth.

But even accepting as appears to be necessary an increase in average velocity along paths as they are taken nearer and nearer to the centre of the earth, the above figures show that this increase is not very great. The inference is that not only has the world a high rigidity, but also that its interior is probably fairly uniform so far as those properties are concerned which determine the rate at which it transmits vibrations. Possibly, therefore, it may have a density throughout its nucleus which is nearly uniform. Unless we assume that as we descend in the earth elasticity and density increase in about the same ratio, to which hypothesis there are objections, it seems likely that the nucleus of the earth has a density that is more nearly uniform than is generally assumed. Prof. Wiechert has shown that such a nucleus made of iron, density 8·2, and four-fifths of the earth's radius, covered by a shell of density 3·2, satisfies the astronomer. Such a world, however, does not comply with what appear to be the requirements of seismology. Iron or steel do not transmit vibrations at the observed rates, whilst chordal velocities within the assumed shell would closely approach those observed along chords which are largely within the core. If a homogeneous nucleus

not less than 19/20 of the earth's radius sufficiently dense and rigid to comply with astronomical tests can be defined, the same might also approximate to the conditions assumed not only by seismologists, but also by physicists. The shell covering such a nucleus would be about 200 miles in thickness. The physical characters of this shell would in all probability change rapidly from those of the crust of the world to those of its nucleus, corresponding to the observed rapid changes in chordal velocities. At a comparatively shallow depth, say 40 miles, high temperatures would result in fusion, and inasmuch as ice, iron, copper and other substances at or near their melting point float on their own solutions, fusion is a state that would partly be promoted by high pressure. At greater temperatures, whatever the pressure might be, fluids would become gaseous, and the gases would be dense, but slightly compressible and viscous. In certain respects, therefore, they would resemble a solid. This is the view of Arrhenius, who assumes a core of gaseous iron the dimension of which is that assumed by Wiechert.

One reason for selecting iron or gaseous iron in an equally dense state is that a nucleus of such material of the specified size will account for the weight of the world as a whole. What, however, is sought for is a body probably a mixture of the commoner elements in a state approaching that of closest crystalline atomic packing, which has a radius 19/20 that of the earth, a specific gravity less than that of iron, but greater than 5.5, which keeps fairly homogeneous, and can transmit compressional vibrations half as fast again as steel. This material may be called *gēite*, a term as much required as *magma* and *crust*, by which gēite is enveloped, and *gēoid*, which refers to the form these materials collectively exhibit.

Whether solid or gaseous, *gēite* may possibly find its chemical equivalent in certain meteorites, and therefore largely consists of iron alloyed with a small proportion of nickel and other elements. If we assume that the shell covering this mixture has a thickness 1/20 of the earth's radius, and an average density of 2·7—the density of the world being taken at 5·5—it follows that the density of the gēite core is 5·96, or approximately 6. The elastic modulus for a core of this density which conveys vibrations with a speed of at least 9·5 km. per second is 451×10^{10} C.G.S., or roughly speaking, a little more than twice the Young's modulus for Bessemer steel (207×10^{10} C.G.S.).

With improvements in seismometrical arrangements, it seems likely that speeds somewhat higher than those here given will be recorded. Within the core itself, a velocity of 9·5 km. per second must be exceeded. For the moment let this be increased to 10 km. per second whilst within the crust let the average speed be 3 km. per second. With such assumptions, if the covering shell is about 40 miles in thickness, the *calculated* times to traverse chords corresponding to axes of 20, 30, 40, 50, 60, 80, 90 and 150 degrees would be 6·1, 7·5, 8·7, 10·2, 11·6, 14·5, 15·7 and 21 minutes. The *observed* times for these paths are 5, 6·5, 8·5, 10·5, 12, 15, 16 and 22 minutes. These approximations between calculations and observations suggest that the region of rapid change between crust and gēite commences where melting temperatures probably prevail.

In venturing these speculations on a geitic core which will satisfy seismometrical and other tests, the fact must not be overlooked that, as earthquake measurements are yet in an embryonic state, figures which have been given relating to the same, although they represent the work of many years, are subject to modification. Amongst the various earth cores which are in harmony with the requirements of astronomy and geodesy, there is at least one which is homogeneous. If the radius of this can be increased 1/7 and it can have the properties of gēite, it will also accord with seismometrical observations.

Other speculations respecting the arrangement and character of materials beneath the earth's crust are based upon the fact that at certain observatories magnetic needles are disturbed by the large waves of earthquakes. These perturbations do not appear to be explained by the assumption that the magnetometers have been tilted. An alternative is to assume that they are due to changes in magnetic intensity possibly brought about, as Capt. E. W. Creak, F.R.S., points out, by changes of stress in a near magnetic medium. If this is the case at those stations where needles are caused to rotate, magnetic intensity and gravity should have abnormal values. This appears to be true for Batavia, near to which there are many volcanoes, indicating the proximity of dense magnetic materials, and for Bombay, where there is basalt, and at no great distance a hidden chain of heavy matter revealed by gravitational observations. At Kew and Greenwich and other stations where needles are not disturbed, magnetic intensity and gravity are not abnormal. Generally speaking, where horizontal force is comparatively low, the difference between the value of g as observed and as expected is also low, and to a certain extent the contrary holds good. On these points, however, until more material has been collected, it is impossible to speak definitely.

What seismometrical observations then lead us to suspect is that beneath the light crust of the earth, which we know to be thinner in some places than in others, there is a magnetic medium of density greater than the crust, which, as we descend in depth, may rapidly pass into a fairly homogeneous nucleus of gēite, the dimensions, physical and chemical characters of which have been suggested.

J. MILNE.

THE SOUTHERN CROSS ANTARCTIC EXPEDITION.

THE magnetic observations made in this expedition[1] have been reduced and prepared for printing by Dr. Chree, F.R.S., and M. Bernacchi, and the meteorological by Commander Hepworth, C.B., and Mr. Curtis, of the Meteorological Office, under the direction of Dr. W. N. Shaw, F.R.S., secretary of the Meteorological Council, and the results have been published by the Royal Society. In this expedition, fitted out by Sir George Newnes, the magnetic observations were made in about equal proportions by M. Bernacchi and Lieut. Colbeck, R.N.R., other observers also giving their assistance in the meteorological work.

The magnetic observations consist of determinations of declination, horizontal force, and inclination, made at Cape Adare, in latitude 71° 18′ south, and longitude 170° 9′ east, with some detached observations of inclination at other places. At Cape Adare observations of declination were made on a number of days in the months of April, May, October, November and December, 1899, giving a mean easterly declination of 55° 49′. Corresponding observations for horizontal force give a mean value (C.G.S. units) of 0.04143, and observations for inclination a mean value of 86° 34′. Observations for the diurnal variation of declination were made on three days, in April and May, 1899, and January, 1900, respectively, giving on the whole a diurnal movement of some 2°, that on the April day

[1] Magnetic and Meteorological Observations made by the *Southern Cross* Antarctic Expedition, 1898–1900, under the direction of M. Borchgrevink, Commander of the Expedition.